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Carderock Division
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Technical Report

Sea Base Utility Vessel

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14. ABSTRACT
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The goal of the Sea Base Utility Vessel design is to develop a concept design to replace helicopters and LCACs in the cargo-carrying role. The SUV should be low cost, yet still capable of operation in Sea State 4 at a service speed of up to 30 knots with a maximum range of 500 nautical miles. It will be able to transport up to 20 LT cargo in various forms in addition to 40 combat ready infantry soldiers. The SUV will be able to offload its cargo in austere port facilities so a shallow draft and onboard cargo handling equipment are requirements. Above all, the SUV will be durable, easily producible, and affordable to purchase and operate.

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Abstract

In the Navy's current Sea Base concept, significant amounts of cargo and personnel require transport over short distances between ships and between ships and shore. This places a heavy transport burden on the Sea Base's helicopters and LCACs, even though neither vehicle is primarily tasked for this duty. Every hour that a helicopter or an LCAC spends ferrying cargo is time that they cannot be performing their primary missions and an hour off their total life. Furthermore, both helicopters and LCACs are resource intensive, requiring a significant amount of maintenance to keep them in operation.

The goal of the Sea Base Utility Vessel design is to develop a concept design to replace helicopters and LCACs in the cargo-carrying role. The SUV should be low cost, yet still capable of operation in Sea State 4 at a service speed of up to 30 knots with a maximum range of 500 nautical miles. It will be able to transport up to 20 LT cargo in various forms in addition to 40 combat ready infantry soldiers. The SUV will be able to offload its cargo in austere port facilities so a shallow draft and onboard cargo handling equipment are requirements. Above all, the SUV will be durable, easily producible, and affordable to purchase and operate.

Executive Summary

The Sea Base is intended to project forward American military power. It allows the Navy to establish a floating base offshore and transport troops and equipment on to the beach or into austere ports. This permits the personnel and equipment stationed on Sea Base ships to be deployed nearly anywhere without permission from other nations.

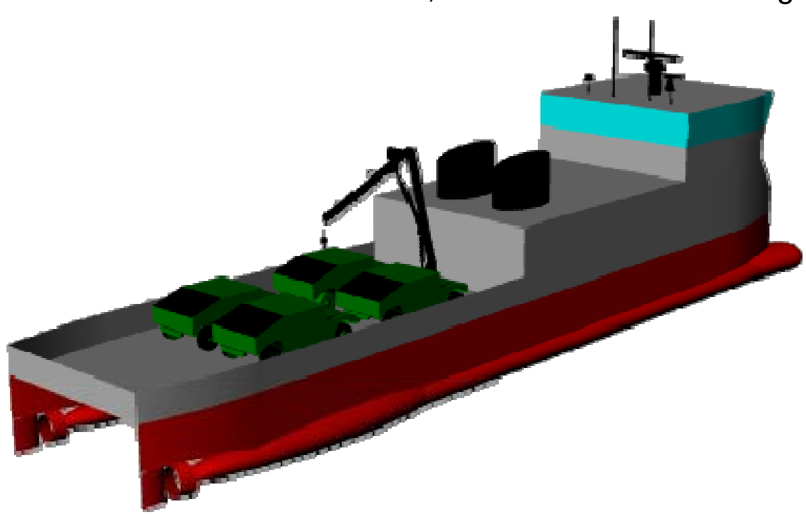
During seabasing operations, a large amount of cargo and personnel transfer will be required as the Sea Base is made up of many constituent naval ships and Military Sealift Command ships, most of which are large and difficult to maneuver.

The current method for cargo transfer relies on either helicopters or landing craft. This solution is not optimal because helicopters and LCACs are expensive to operate and transferring cargo prevents them from performing the missions for which they are primarily designed. Displacement hull landing craft are also not ideal because their required geometry for landing operations leads to poor seakeeping.

To alleviate this problem, the Sea Base Utility Vessel was designed as a fast and efficient craft for transporting cargo and personnel between ships in the Sea Base and from the Sea Base to shore. The Sea Base Utility Vessel (SUV) is a 130.5-foot aluminum SWATH ship with a 28.9-foot beam and a 6.2-foot draft. The SUV displaces 179 LT. It is capable of 30 knots and has a range of 500 nm at this speed. The SUV can operate in conditions up to Sea State 4.

With a 20 LT cargo capacity, the SUV will be able to accommodate 4 HMMWV's, which can be loaded and offloaded at the Sea Base by one of the larger ships using that ship's cranes. Solid cargo can also be loaded and offloaded in an austere port by the 10-ton crane mounted on the cargo deck of the SUV. In addition to solid cargo, the SUV is designed to transport as many as 40 fully equipped infantry in a space modeled after a long-haul commercial airline cabin. The ship has a small onboard galley and three heads which can support the passenger contingent as well as the 3 to 6 man crew.

The SUV has a fully integrated electric distribution system powered by 3 Detroit MTU model number 16v4000 M61R diesel engines supplying 6114 SHP. The system supplies power for both propulsion and the hotel load. The SUV's maximum range is 2,100 nm at 10 knots on internal tanks or 4,500 nm at 10 knots using external cargo fuel tanks.



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List of Abbreviations and Acronyms

ASW	Anti-submarine warfare
BM	Distance from center of buoyancy to metacenter
CISD	Center for Innovation in Ship Design
CONOPS	Concept of operations
GM	Distance from center of gravity to metacenter
HMMWV	High Mobility Multipurpose Wheeled Vehicle, Humvee
HSSL	High Speed Sea Lift
KB	Height of center of buoyancy
KG	Height of center of gravity
kg/kw-hr	kilograms per kilowatt-hour
KM	Metacentric Height
LT	Long ton
LCAC	Landing Craft Air Cushioned
MEU	Marine Expeditionary Unit
MSC	Military Sealift Command
MT	Metric ton
nm	Nautical mile
NRIEP	Naval Research Enterprise Intern Program
NSWCCD	Naval Surface Warfare Center, Carderock Division
ONR	Office of Naval Research
SUV	Sea Base Utility Vessel
SWATH	Small Waterplane Area Twin Hull
SWBS	Ship Work Breakdown Structure

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Mr. John Stebe

Section 1 - Introduction

1.1 Mission Statement

The goal of this project is to design, to a conceptual level, a high performance vessel that facilitates the transfer of cargo and personnel between ships in a Sea Base and from ship to shore in high sea states while minimizing cost. The original requirements are provided in Appendix A. This will allow helicopters and LCACs to be re-tasked to their primary missions. This craft is known as the Sea Base Utility Vessel or SUV.

1.2 Background

In the current model of the Sea Base, many ships congregate to form a floating port. The Sea Base is intended to project forward American military power without relying on allies' bases. The Sea Base allows the Navy to set up a floating base offshore and transport troops and equipment on to a beach or into austere ports. This provides the personnel and equipment stationed on Sea Base ships to be widely deployed.

The Sea Base is made up of many constituent naval ships and Military Sealift Command ships, most of which are large and difficult to maneuver, especially in the open ocean sea states in which the Sea Base will be operating. For this reason, among others, skin-to-skin docking between these ships for the transfer cargo is difficult.

The current solution to the Sea Base cargo transfer problem involves moving cargo and personnel via helicopters and landing craft. Helicopters and LCACs cost thousands of dollars per hour to operate and can be used for more specialized missions, such as ASW and landing operations, for which they are primarily intended. Displacement hull landing craft are a poor option due to poor seakeeping characteristics caused by the geometric constraints that allow them to land equipment and troops on the beach. None of these options offer the Sea Base commander a quick, reliable, efficient and cheap method of cargo transfer between ships or from ship to shore.

Section 2 - Mission

2.1 Cargo Carrying Capabilities

This ship shall be able to carry 20 LT of solid cargo in various forms. Based on current Marine Expeditionary Unit (MEU) vehicles, it was determined the least dense 20 LT cargo would be 4 HMMWVs (humvees). The dimensions of a humvee are provided in Appendix B. In addition to solid cargo, the SUV shall carry 40 fully equipped infantry. Each soldier, fully armed, was assumed to weigh 250 lbs.

2.2 Performance Capabilities

The SUV shall have a range of 500 nm at 30 knots. It will possess a shallow draft and cargo handling facilities to enable operations in austere or unimproved ports. The ship will also be able to maintain speed and perform cargo transfer operations in up to Sea State 4.

2.3 Other Requirements

The ship should be manufactured and operated as economically as possible.

2.4 Visual Representation of CONOPS

Figure 1 gives a visual representation of the CONOPS of the SUV as an intra-Sea Base cargo transfer ship.

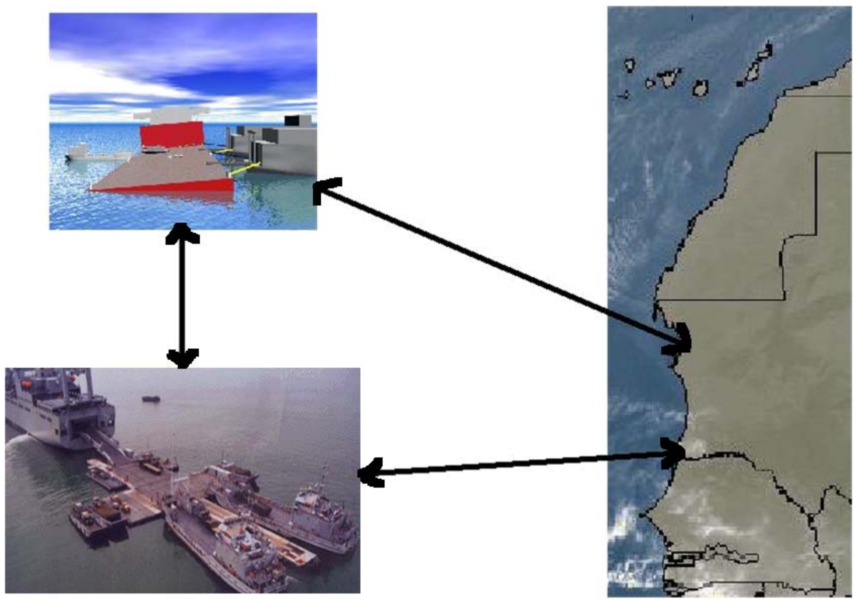

Figure 1: CONOPS of the SUV

Section 3 – Concept Development

3.1 Hullform

The four hullforms considered for the SUV design were the monohull, Small Waterplane Area Twin Hull (SWATH), and catamaran hullforms. The criteria used to select the hullform (starting with the most important) were: stability, seakeeping, cost, powering, cargo area, and ease of construction.

The catamaran was discarded as a feasible hullform because, compared to the other multi-hull hullform considered, it offered the fewest advantages in seakeeping.

The monohull is a proven design that the Navy is comfortable with and is comparatively inexpensive to build. There exists a large amount of resistance data as well as many variations of the hullform to work with. The main issues with small sized monohulls are the power requirements to reach high speeds and poor seakeeping characteristics in elevated sea states.

SWATHs offer better seakeeping than monohulls of a similar size. The drawbacks to the SWATH hullform are that it is more expensive to construct and typically has a deeper draft. Despite these disadvantages, the SWATH was chosen because of its seakeeping advantages, the potential for a large amount of deck space, and the low speed control characteristics which assist in Sea Base cargo transfer. Figure 2 shows a typical SWATH hullform.

Figure 2: Typical SWATH

3.2 Specific Hull Design

Instead of designing a new hullform, an existing hullform was scaled to fit the SUV. The hullform chosen for the SUV was the HSSL (High Speed Sea Lift) hull developed by Bath Iron Works. This hullform was chosen because the SUV is intended to operate at a Froude number of 0.78, and the HSSL hullform has low resistance in this range. Additionally, the hullform has good seakeeping characteristics at high speeds, there is a large amount of resistance data available, and the hullform has a shallow draft relative to other SWATHs. In order for the SUV to have the same hullform characteristics, the HSSL was proportionally scaled down to fit the SUV's requirements. A rendering of a HSSL demi-hull is shown in figure 3.

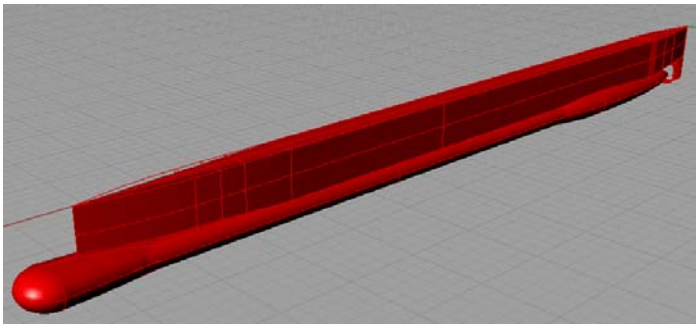

Figure 3: HSSL Demi-Hull

3.3 Propulsion

Three methods of propulsion were considered for the design of the SUV: gas turbine geared drive, diesel geared drive, and diesel fully integrated electric drive. The ship required a system that utilized existing reliable technology while being as cost efficient as possible. For that reason it was decided that gas turbines were not an option. While they are easily available as an off the shelf technology, their cost is excessive at this scale making them an undesirable choice.

Diesel geared drive was the least expensive mode of propulsion considered. It is simple and the components are readily available from existing propulsion applications. However, it was determined that for a SWATH of the size of the SUV, diesel prime movers of sufficient size would not fit inside the lower hulls. That would require the prime movers to be located above the struts of the hulls, requiring right angle gears to connect to the propulsors. This was not an acceptable arrangement because of the poor reliability of right angle gears.

Consequently, diesel fully integrated electric drive was selected as the best option for the SUV. While it is more expensive than diesel geared drive, fully integrated electric drive allows for flexibility of arrangements and eliminates the need for right angle gears. This will allow the ship to be more reliable and better arranged. A small efficiency loss was outweighed by other benefits.

3.4 Structural Material

The speed and sea state requirements drove the selection of the hull material. Composites, titanium, steel, and aluminum structures were all considered as options for the SUV. Titanium was not selected because of the expense and the uncertainties that accompany titanium shipbuilding on a large scale. Composites were not selected because of concerns that they could not handle the large loads that a vessel like the SUV would face over time without significant technical risk. Steel and aluminum could easily handle the structural loads over the life of the ship. The deciding factor between the two materials was weight. Aluminum is stronger per unit weight than steel. A lightweight hull was crucial to meet the requirement of thirty knots. Selecting aluminum as the structural material made the ship lighter thus needing less power to meet the speed requirement.

Section 4 – Ship Particulars

Table 1 shows the characteristics that were generated because of the SUV design.

Length (ft)	130.5
Beam (ft)	28.9
Draft (ft)	6.2
Propulsion	3 x 16v4000 M61R Detroit MTU Diesel 6114 SHP
Speed (knots)	30
Range (nm)	500
Operational Capability (sea state)	4
Cargo Capacity (LT)	20
Personnel Capacity	40
Complement	3-6
Displacement (LT)	179

Table 1 : General Characteristics of the SUV

Details of the hull geometry are in Appendix C.

Section 5 – General Arrangements

5.1 Overview

The SUV is a 179 LT aluminum SWATH ship. It consists of twin hulls, one main deck and a superstructure. A 3-D rendering of the ship is shown in Figure 3.

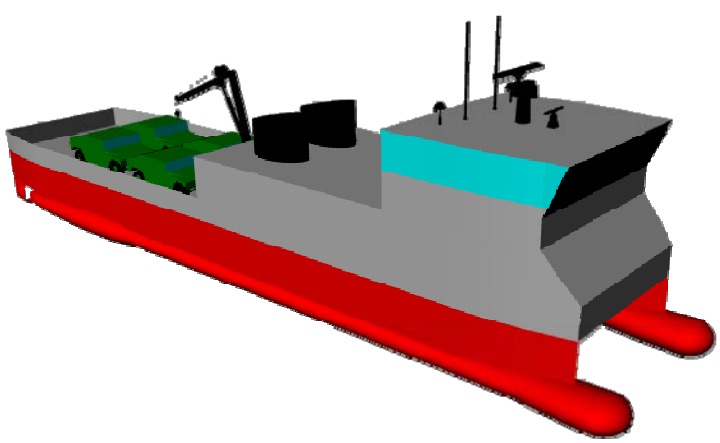

Figure 4: Rendering of the SUV

5.2 Twin Hulls

The twin hulls are 120.3 feet long and have a maximum diameter of 5.4 feet. They house the motor and steering gear rooms at their aft end. Forward of the propulsion spaces are ballast tanks. Continuing forward there is a tank for the waste oil produced by the engines, as well as the fuel tank forward of the bulkhead. The fuel tank in each demi-hull holds half of the craft's 16.2 LT of fuel. These tanks are interconnected so that fuel may be pumped from one side of the ship to the other in order to heel the ship during cargo transfer operations. Forward of the fuel tank bulkhead are tanks for black water, grey water, potable water, and forepeak ballast. The inboard profile drawing can be is shown in Figure 5 and a larger version is included in Appendix D.

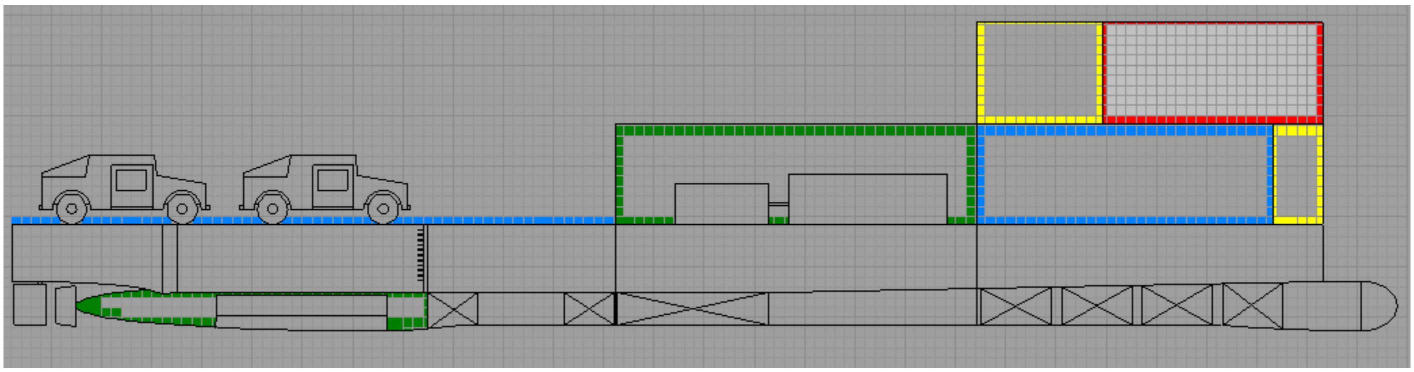

Figure 5: Inboard Profile Drawing
Green: Machinery Spaces, Blue: Mission Spaces, Yellow: Habitability Spaces, Red: Ship Control Spaces

5.3 Main Deck

On the main deck, there are three areas. The main cargo deck is furthest aft. The compartment forward of the cargo deck is the machinery room. The forward most compartment is the troop transport mission space. The plan view of the main deck is located in Appendix E.

5.3.1 Cargo Deck

The cargo deck composes the aft part of the main deck. It is 60 feet long and extends across the full beam of the ship. The deck will support the required 20 LT loads. The cargo deck was sized to carry the least dense cargo of the MEU which was 4 "humvees. The cargo deck has multiple integrated tie-down points on the deck which allow the crew to embark cargo of different dimensions and lash it down securely.

On the forward edge of the cargo deck is a representative 10-ton crane. The 10-ton crane was selected because larger cranes were heavier and lifting larger weights over the side of the ship would cause high heel angles. The crane selected can lift cargo at .7 feet per second and is capable of moving ten tons of cargo through a radius of eight to forty feet. This will allow the crew to move cargo about the deck as well as to offload it to shore facilities.

5.3.2 Machinery Room

Forward of the cargo deck is the machinery room containing the ship's prime movers and generators. The prime movers are three Detroit MTU diesels, model 16v4000 M61R, each delivering 2,038 SHP. These engines drive generators, which provide electrical power for the electric motors in the hulls as well as hotel services. The engines and generators are arranged in an in-line fashion with engines forward of generators. Outboard of the engines are passageways, one to port and one to starboard, which provide access from the troop transport mission space to the cargo deck.

5.3.3 Troop Transport Space

The forward most compartment on the main deck is the troop transport space. The space that is designed to transport 40 fully equipped combat troops in relative comfort. It is equipped with 40 seats modeled after long-haul airline seats. The seats recline to 81 degrees, affording the troops a nearly horizontal surface for sleeping. The compartment is sound insulated from the engine room so that the troops can be briefed on their mission or sleep. This compartment also houses the ship's heads and galley. Three heads support the troops during transit and the crew of the ship. A galley is provided so that the crew of the ship can be fed during an extended transit or deployment.

5.4 Superstructure

Above the troop transport space is the superstructure. The superstructure houses all of the command and control spaces as well as the berthing spaces for the crew of the SUV. The berthing space provides berths for six crewmembers. The command and control section occupies the forward half of the. An arrangement plan is provided in Appendix F.

Section 6 – Propulsion

6.1 Design Drivers

One of the largest design drivers for the SUV is the 30-knot speed requirement. It was necessary to ensure that the ship had enough power to achieve the design speed while also minimizing the weight and space that the power plant occupied. As discussed in section 3.2, fully integrated electric propulsion was selected to power the SUV.

6.2 Powering Calculations

To calculate the power required to achieve 30 knots, it was necessary to calculate the resistance. Resistance data measured in the HSSL model tests conducted by Bath Iron Works was scaled to SUV size. Figure 6 shows the shaft horsepower required to propel the SUV at various speeds.

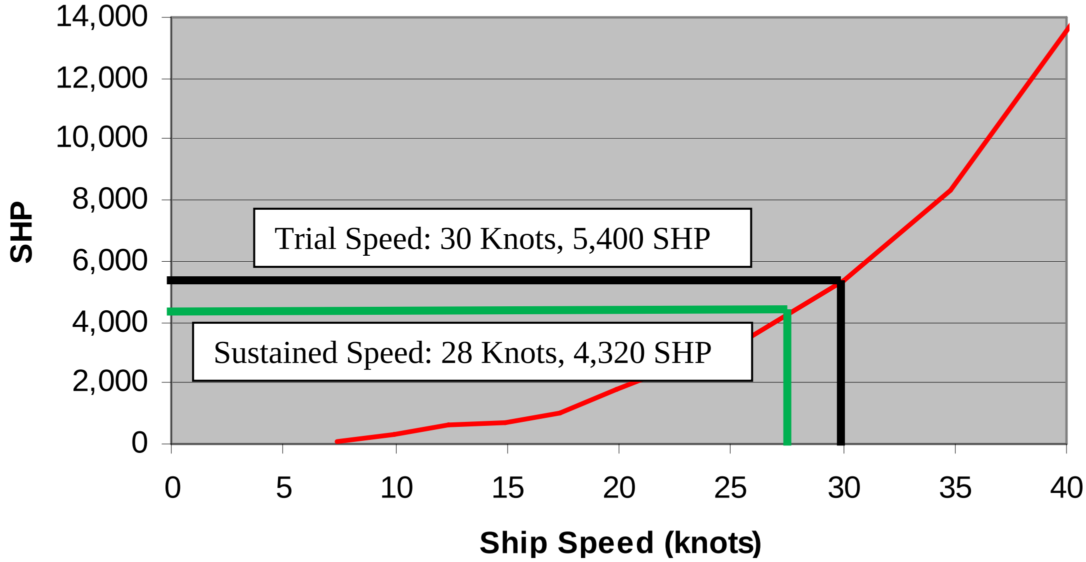

Figure 6: SUV Powering Requirements

The resistance data showed that it was necessary to install 5,400 shaft horsepower to provide a trial speed of 30 knots. Sustained speed at 80% of this power is 28 knots. This requirement was in a range of the powering curve where diminishing returns start to set in, and it was therefore decided that equipping the SUV with a power plant capable of propelling the ship over 30 knots would be exceedingly expensive and unnecessary.

6.3 Engine Selection

Three 16v4000 M61R Detroit MTU diesels, pictured below in Figure 7, were selected for power generation. They provide a total of 6,114 SHP which will power the SUV at full speed while still providing 450 KW for ship service loads. These engines were selected because they only occupy 16.2 cubic meters each and have a specific fuel consumption of 0.206 kg/kw-hr, which is efficient for engines of this size.

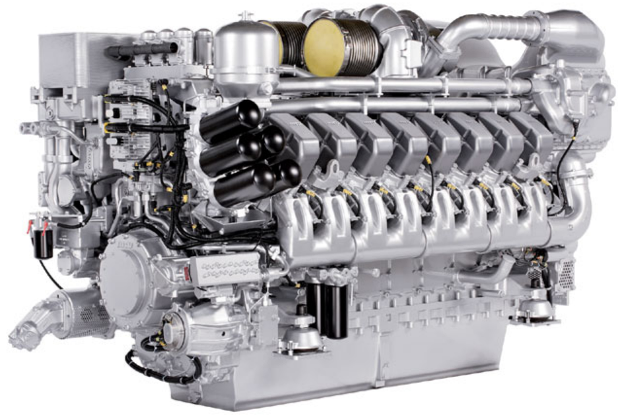

Figure 7: Detroit MTU Diesel Engine Model 16v4000 M61R

6.4 Electrical System

The SUV is a fully integrated electric ship. The diesel engines provide mechanical power that is then converted to electricity by generators. From there, the power is distributed to switchboards which divide power between the propulsion motors and hotel services. A schematic of the system is shown below.

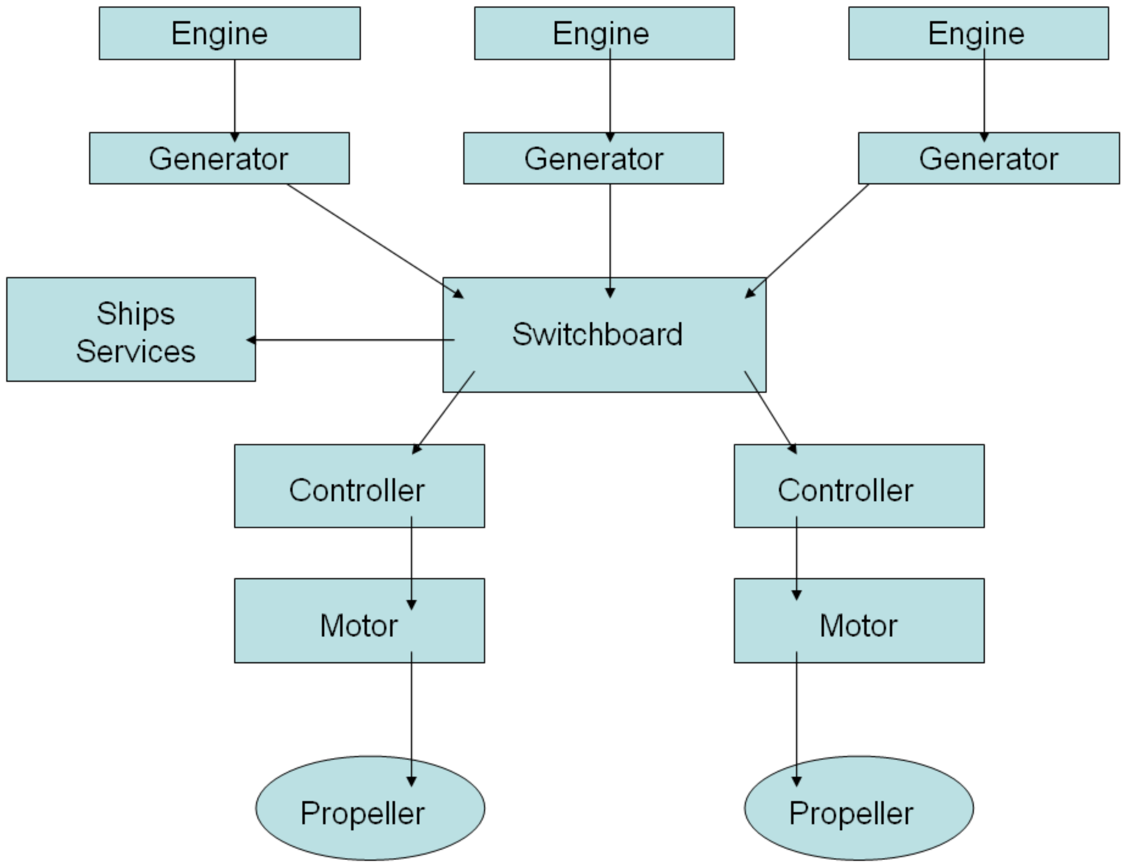

Figure 8: Schematic of the SUV's Electrical Distribution System

6.4.1 Generators

The SUV will be equipped with three AC generators. Weight and space estimates for the generators were scales from the X-Craft.

6.4.2 Switchboard, Controller, Miscellaneous Electrical Components

The electric system will be low voltage, AC system. The remaining electrical components including the switchboard and motor controller, have been given weight allowances, but no definitive choice of components has been made.

6.4.3 Motors

The propulsion induction motors for the SUV were based on motors custom built by Siemens for X-Craft. The weight and size data for the induction propulsion motors was scaled from the electric motors onboard the X-Craft.

6.5 Propeller Selection

Propellers were selected for the SUV over a waterjet system because propellers are more efficient than waterjets in the operating range of the SUV. The propellers on the SUV were sized to avoid extending below the keel to avoid increasing the draft of the ship.

6.6 Range and Fuel

The required range for the SUV is 500 nm un-refueled. A transit speed of 25 knots was selected. At 25 knots, the SUV would be required to have enough fuel to operate for 20 hours. These parameters combined with the specific fuel consumption rate of .206 kg/kw-hr, were used to support a DDS 200 endurance calculation. The SUV requires 16 LT of fuel for this endurance. Figure 6 shows the different ranges that are achievable with this fuel load by varying the transit speed of the ship.

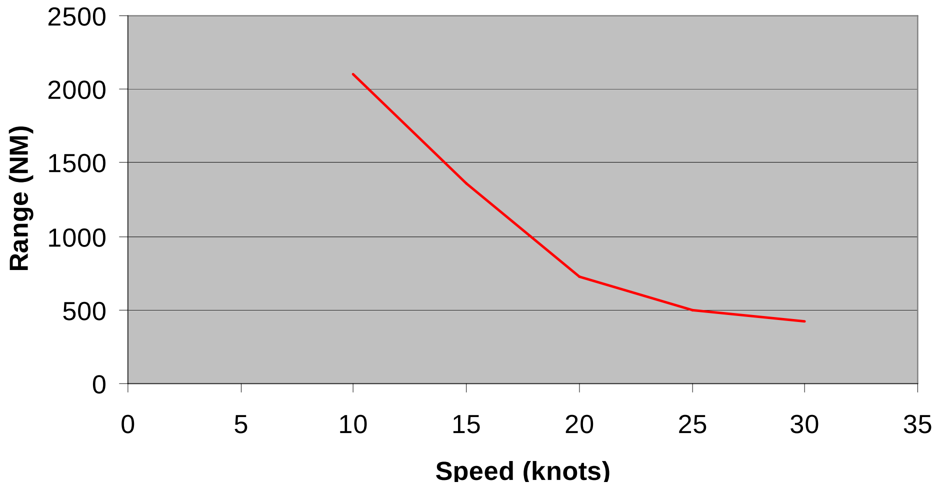

Figure 9: Ship Range Dependence on Endurance Speed

The SUV is of going as far as 2,100 NM at a transit speed of 10 knots. This wide-ranging endurance capability makes the SUV a flexible ship that can be called upon for a variety of missions.

Section 7 – Weight Estimate

7.1 Ship Weight Breakdown Structure Overview

The Ship Weight Breakdown Structure was used to estimate the weights of the SUV. Table 2 gives a one digit summary of the weights. A more detailed weight breakdown is provided in Appendix H.

SWBS Group	Weight (LT)
100 Hull Structures	33
200 Propulsion	37
300 Electrical Plant	7
400 Command and Control	3
500 Auxiliary Systems	26
600 Outfit and Furnishing	18
700 Armament	0
Lightship	**123**
800 Deadweight	42
900 Margin (11%)	14
Full Load	**179**

Table 2: Weight Summary

7.2 SWBS Group 100 - Hull Structures

The weight estimate for the hull structure was developed from a plot of structural densities of existing aluminum high speed ships (see Appendix I). A structural density for the SUV was selected that fell in between the most robust and the most lightweight designs. A structural density of 2.1 lbs/ft^3 was selected for the useful volume ratio of 0.6 that the SUV possesses. The total volume of the SUV was multiplied by the structural density to give the weight of group 100 as 33.2 LT.

7.3 SWBS Group 200 - Propulsion

The weight estimate for the propulsion units were made from two sources. The estimates of the prime movers were based on vendor data provided by Detroit Diesel. The weights for the electric motors were scaled from the weights for the electric motors on the X-Craft. The estimate for group 200 also includes an allowance for operating fluids and repair parts.

7.4 SWBS Group 300 – Electrical Plant

The electrical plant data for the SUV was scaled from the X-Craft, based on the relative power outputs of both plants. The weight estimate for this group also includes wiring, conduit, switchboards, circuit breakers, and all other equipment associated with the electrical system.

7.5 SWBS Group 400 – Command and Control

The weight estimate for the command and control facilities was on a component-by-component basis. This group's weights included all of the navigational equipment, radar, and communications. The components' weights were mainly based on manufacturer's data, but some items were scaled down from the X-Craft.

7.6 SWBS Group 500 – Auxiliary Systems

The weight estimate for the auxiliary systems was scaled from the X-Craft. This group includes all of the climate control systems, water systems, fire control systems, and ship handling systems. The climate control systems and water systems were scaled based on the volume of the ship. The rest of the auxiliary systems were scaled by the overall displacement of the ship.

7.7 SWBS Group 600 –Outfit and Furnishing

The weight estimate for the outfit and furnishings was scaled from the X-Craft. This group includes all of the paint, bulkheads, hardware, and furnishings on the ship.

7.8 SWBS Group 700 – Armament

The SUV is not required to carry armament on board. Therefore, there is no weight assigned to group 700.

7.9 SWBS Group 800 – Deadweight

Deadweight for the SUV includes fuel, cargo, and the weight of the crew. The fuel weight was calculated to be 16 LT as discussed in Section 6.5. The cargo weight was the SUV design requirement of 20 LT. The other weights were determined based on Navy standards for habitability for the crew. The total deadweight was 42 LT.

7.10 SWBS Group 900 – Margin

The design team incorporated an 11 percent margin into the design of the SUV. The 11 percent margin equates to 13.6 LT and brings the total displacement of the ship to 179 LT.

Section 8 – Hydrostatics

8.1 Overview

The SUV will be required to perform cargo transfer at sea in adverse sea states. There are many things that pose a threat to the stability of a ship during cargo transfer at sea. If at any time the ship were to become unstable, the results for the ship, the cargo, and the crew could be disastrous. Therefore verifying the stability of the ship under loading situations was crucial.

8.2 Fully Loaded Stability

The design team calculated the fully loaded stability of the SUV manually. Table 3 shows the findings:

KG (ft)	12.1
KB (ft)	3.0
BM (ft)	11.5
KM (ft)	14.6
GM (ft)	2.5

Table 3: Static Stability Values

A GM of 2.5 feet is nine percent of the beam which is consistent with other SWATHs. This metacentric height was calculated without water ballast on board which demonstrates that the SUV does not need to be ballasted to be stable with the full 20 LT of cargo loaded on the deck.

8.3 Unloaded Stability

The SUV stability with no cargo and minimal fuel onboard was also confirmed. The GM in this condition is 1.8 feet. That is slightly lower than the desired metacentric height for a ship of this size. However, GM can easily be increased by using seawater ballast.

8.4 Righting Arms

Intact stability at large angles of heel was evaluated. Figure 7 shows the righting arms calculated for the SUV.

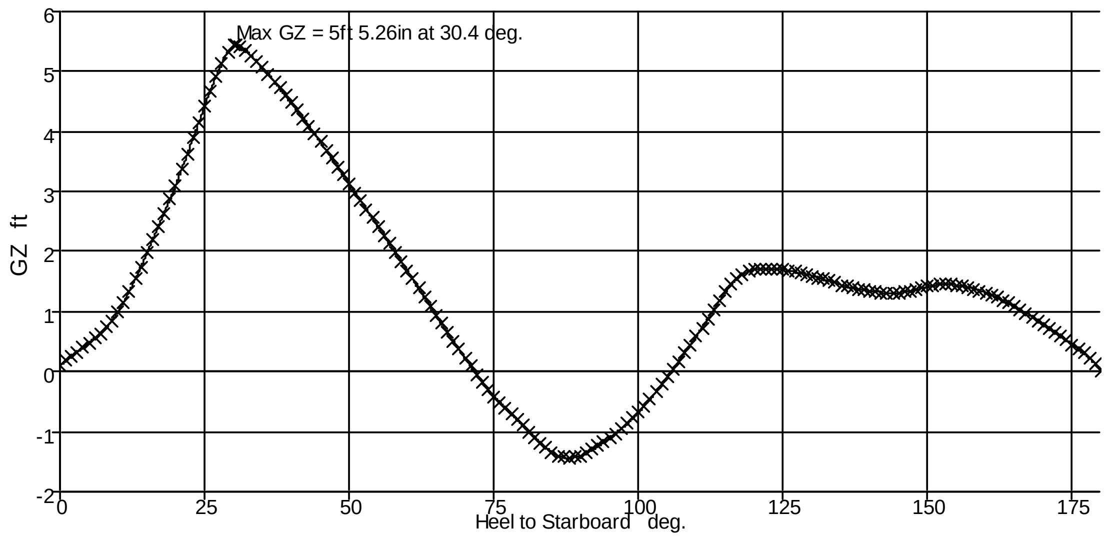

Figure 10: Righting Arms

As shown in by Figure 7, the SUV will have a positive righting arm up to 70 degrees of heel. The maximum righting arm occurs at 30.4 degrees and has a magnitude of 5'5''.

8.5 Cargo Loading Operations

The large weights method was used to confirm that the ship would remain stable throughout cargo loading operations. It was confirmed that the ship would remain stable even with the cargo crane hoisting a 10-ton load out to forty feet from the centerline. In this extreme condition, the SUV will heel 16º and have a positive righting arm. Taking on ballast to lower the elevated side of the ship can further reduce the 16º heel created by this cargo-handling situation.

Section 9 – Inter-Theater Transport

The original intent was to have the SUV "piggybacked" into theater onboard a heavy lift ship. The US Navy has used these ships in the past to move support assets such as mine countermeasure ships. However, this relies heavily on the availability of the heavy lift ships. Consequently, other options for transporting the SUV were explored. The alternates identified were:

1). Self Powered Transit
2). Pre-deployment
3). Towed Transit

The SUV could be towed by another ship headed to the Sea Base, but that would be a very slow and complex process.

The two most appealing options were pre-deployment and self powered transit. In pre-deployment, SUVs would be stationed strategically so that they could be wherever the Sea Base was in a short period. While this was an acceptable solution, the SUV could still be farther from the Sea Base than it could transit un-refueled. Carrying additional fuel as deck cargo in temporary fuel tanks to increase the range of the ship was explored. Figure 10 shows the range of the SUV with 20 LT of added fuel in red, while the range with the standard load of fuel is in blue.

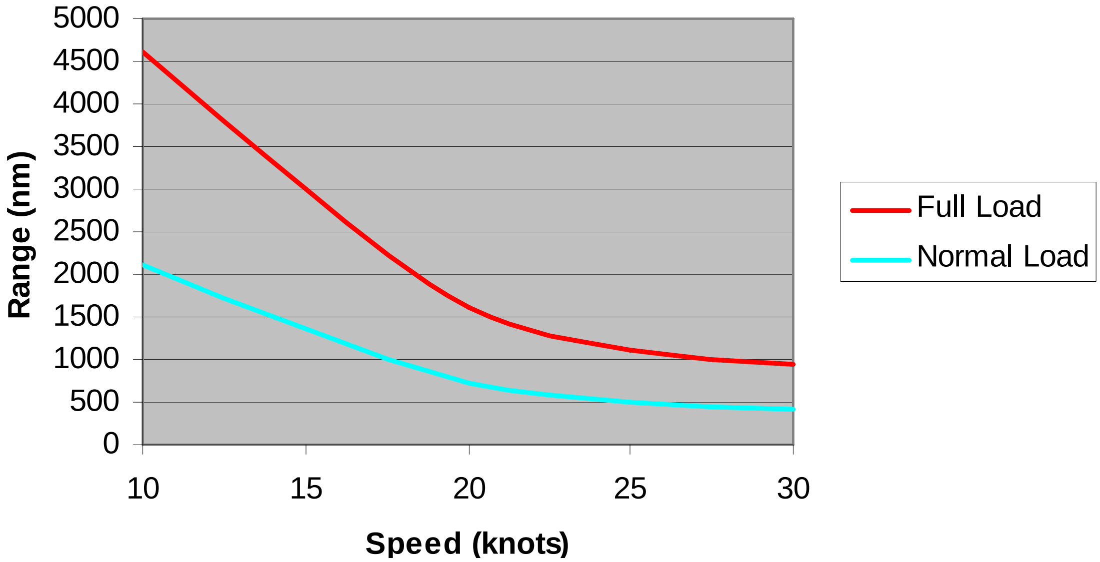

Figure 11: Range versus Speed with a Normal Fuel Load and with an Extra 20 LT of Fuel Embarked

The graph shows that by embarking the additional load of fuel and slowing the transit speed to ten knots, the SUV has a range of over 4,500 nautical miles. Transit time at this speed would require 19 days. This gives the ship the un-refueled range necessary to reach a Sea Base. This increases the operational efficiency of the SUV and decreases the costs of operation as it is independent of other transportation systems.

Section 10 – Conclusion

10.1 Summary

The Navy's current solution for transporting cargo and personnel in a Sea Base diverts helicopters, LCACs, and displacement hull landing craft from their primary missions. This is an inefficient use of resources because these vehicles were not designed to perform this task. The introduction of the Sea Base Utility Vessel into the fleet would allow the helicopters, LCACs, and displacement hull landing craft to be reassigned to their intended higher value missions while offering a better platform to transport cargo and personnel within the Sea Base. The SUV is a high performance yet economical ship that is capable of operations in the open waters of a Sea Base and in the constricted waters of an austere port. The SUV will be able to provide the Navy with fast, efficient, and economical cargo transfer services.

10.2 Future Work

In future design iterations of the SUV, motions and cargo transfer at sea should be investigated thoroughly as it has many unknowns and is a vital aspect of the ship's mission. A study is recommended to investigate the best methods of cargo transfer as well as the interactions between the SUV and the other ship during that operation.

The weight estimate should be further refined. Finally, subsequent design iterations should include a detailed seakeeping and performance analysis to confirm that the SUV will be able to meet its operational requirements. Overall, there do not seem to be significant issues with the design of the SUV. Subsequent design iterations should further reduce those risk areas.

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6. Paik, Jeom Kee, Owen F. Hughes, Paul E. Hess, and Celine Renaud. "Ultimate Limit State Design Technology for Aluminum Multi-Hull Ship Structures." 2005. May-June 2008 <http://www.shipstructure.org/project/1446/smtc-2005.pdf>.

Appendix A – SUV Initial Brief

Introduction

1. The current Seabasing paradigm requires a significant amount of short distance transportation of irregular cargo, on demand between two vessels or between the Sea Base and the shore.

2. At present helicopters and landing craft are used for this requirement but neither approach is ideal. Helicopters and Air Cushion Landing Craft are in short supply and are resource intensive. Displacement Landing Craft are compromised by the conflicting demands of amphibious operations and cargo capacity and as a result are generally poor in a seaway.

3. A Sea Base Utility Vessel is required that provides a reliable cargo and personnel transport system between ships in a Seaway and to austere ports ashore.

Aim

4. To design at a conceptual level a low cost but high performance vessel capable of transporting personnel and solid cargo in high Sea States between two Sea Base vessels or from the Sea Base to an austere port.

Ship Design Requirements

5. The vessel shall possess the following properties:-
6. A minimum draught.
7. A range of 500 Nm and service speed of 25-30 knots
8. The ability to carry solid cargo in various forms up to 20 tonnes. The ability to transport 40 personnel up to and including fully equipped infantry in marching order.
9. Methods of delivering and loading cargo and passengers to and from Sea Base vessels and austere port piers.
10. Seakeeping appropriate to maintenance of the service speed in Sea State 4 and during cargo and personnel transfers in up to Sea State 4.

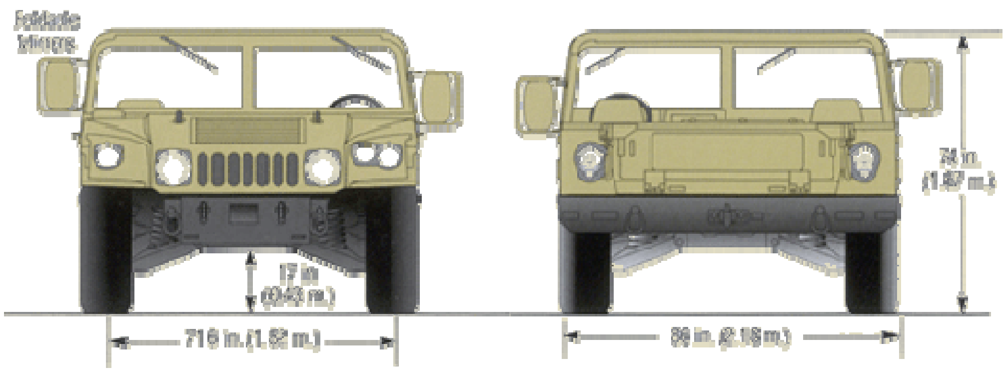
Areas of Technology Exploration

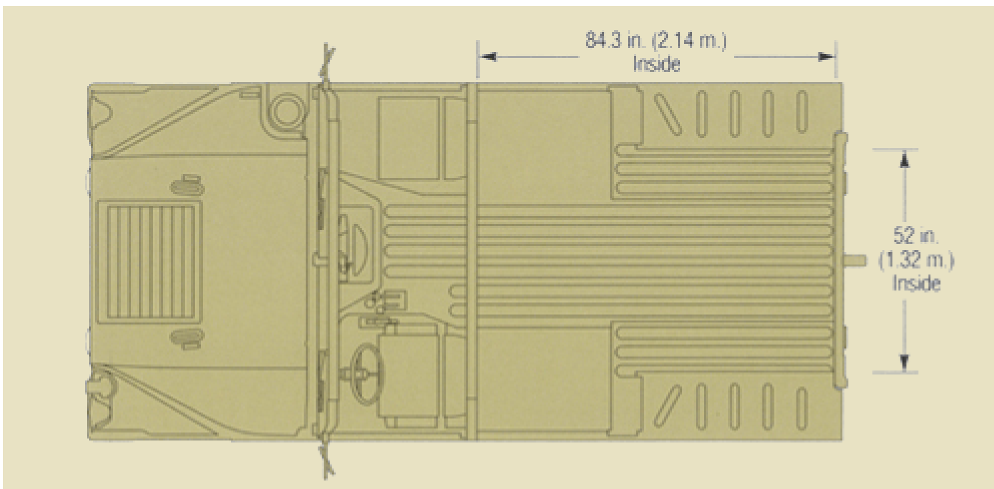
11. The following areas are to be especially developed:-
12. Seakeeping performance at maximum speed.
13. Cargo and Passenger transfer in sea states.

Constraints

14. The constraints upon the design are as follows:-
15. The vessel shall be designed to ABS’s version of the High Speed Code Rules
16. The vessel shall not have any additional survivability or military features
17. The vessel’s cost shall be minimized.

Appendix B – HMMWV (Humvee) Dimensions





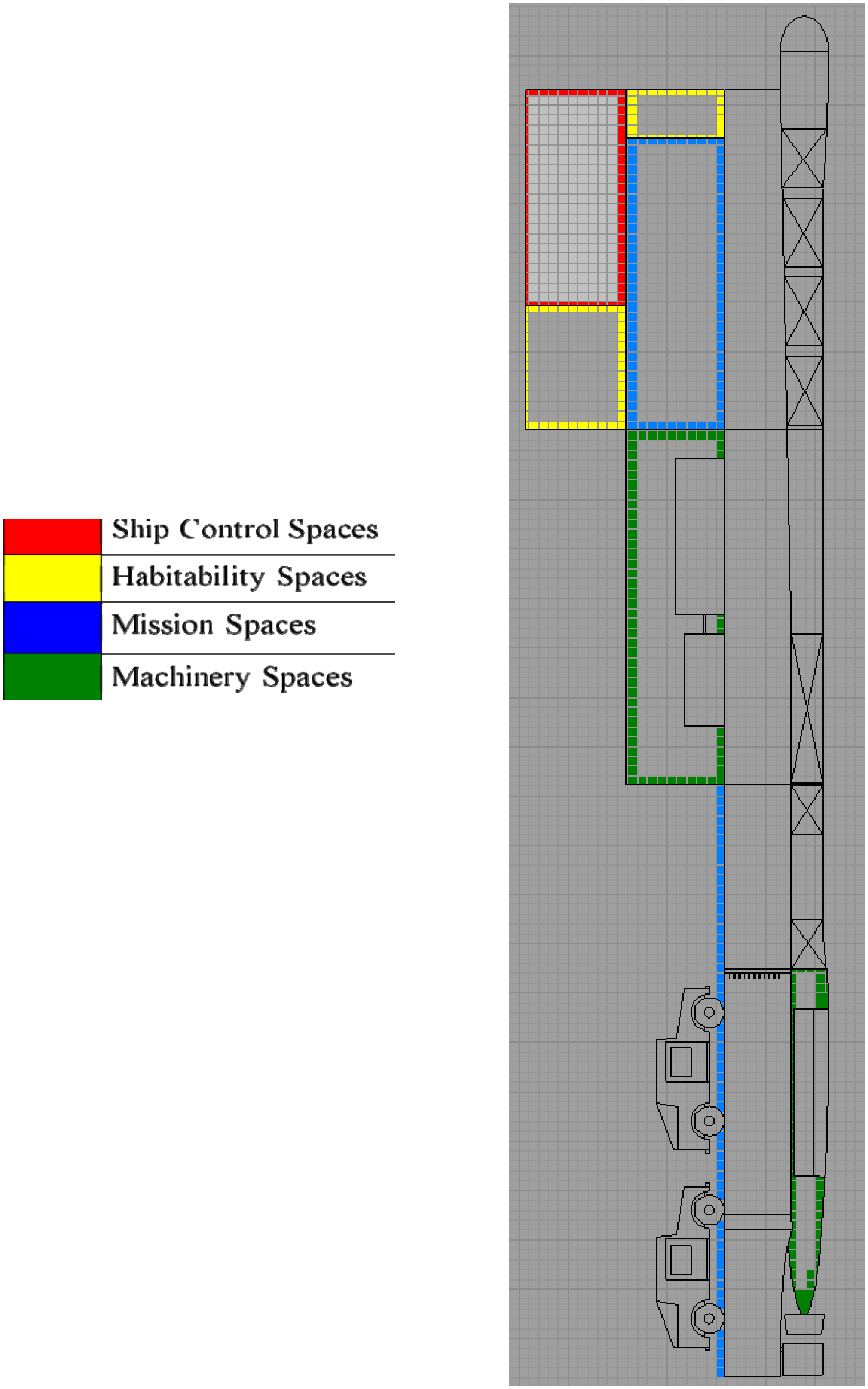
Length	15.875 ft
Width	7.17 ft
Height	6.17 ft
Weight	5,200lbs/2.32LT

Humvee Dimensions
(amgeneral.com)

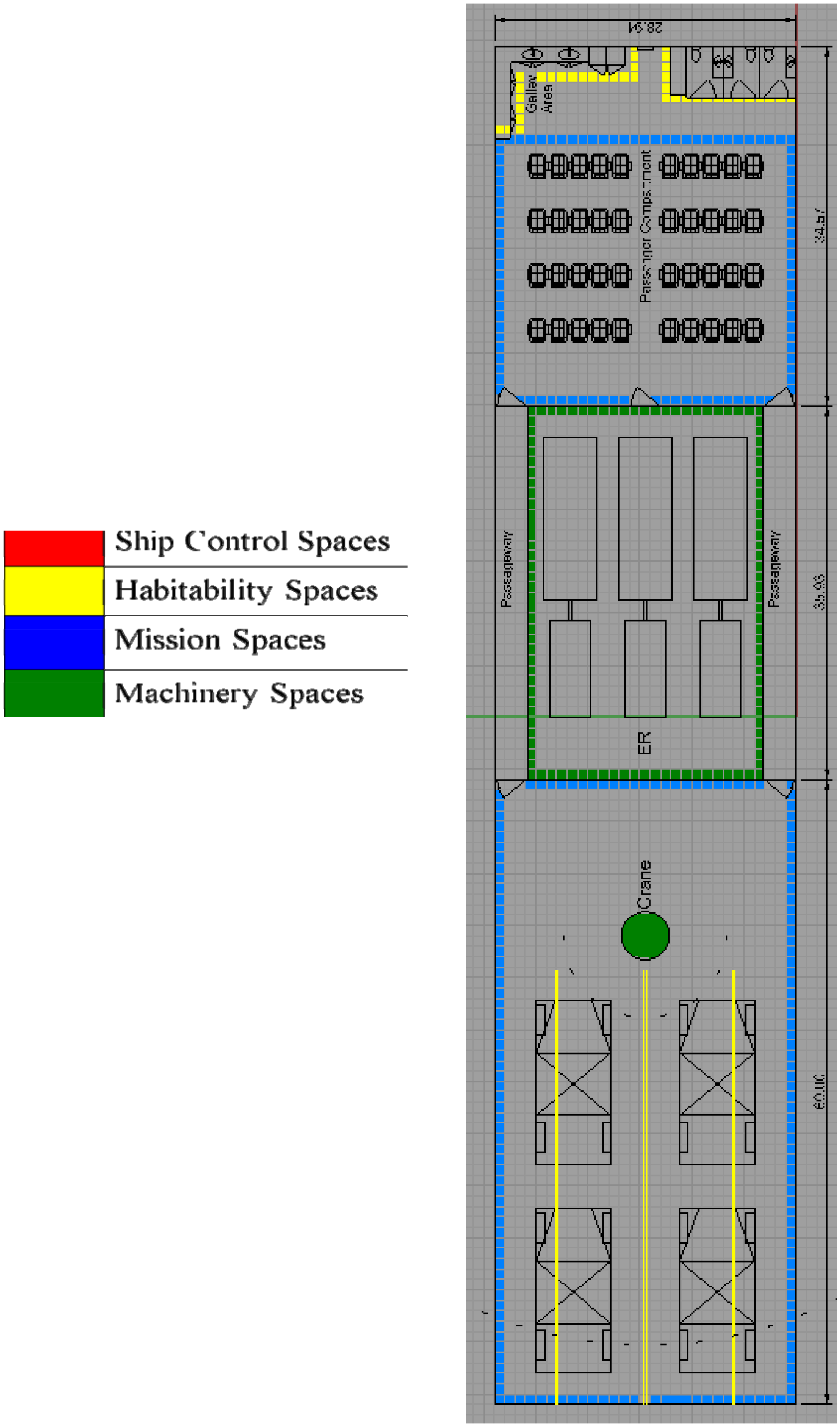
Appendix C – Sizing Breakdown

Input Displacement			**Fixed Data from HSSL model**	
Displacement (LT)	**179**			
			Length-waterline (ft)	530
			Length-overall (ft)	560
			Beam-waterline (ft)	117.5
			Beam-overall (ft)	131.3
Design Dimensions			Draft (ft)	25.1
Length-waterline (ft)	130.54		Disp (LT)	$1.2x10^4$
Beam-waterline (ft)	28.940		Disp (cu ft.)	$4.32x10^5$
Draft (ft)	6.1820		WS (sq ft)	71,402
Strut Width (ft)	3.7486		Strut Width (ft)	15.220
Strut Length (ft)	124.31		Strut Length (ft)	504.70
Strut Height (ft)	6.8273		Strut Height (ft)	27.720
Hull Height (ft)	5.3890		Hull Height (ft)	21.880
Strut Above Water Height (ft)	6.0342		CB	0.27637
			Disp Scale Factor	0.01494
			Linear Dimension Scale Factor	0.24630
Displacement Balance				
Weight Estimate (LT)	179			
Displacement (LT)	179			
			Volume model	
Displaced Volume (cu ft)	6,454.4		Underwater Volume (cu ft)	6,436.5
			Strut Above water volume (cu ft)	2,811.8
			Superstructure Volume (cu ft)	26,201
			Deckhouse Volume (cu ft)	
			Total Volume (cu ft)	35,449

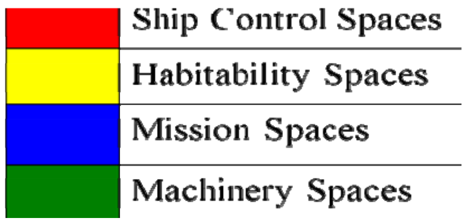
Appendix D – Inboard Profile Arrangement

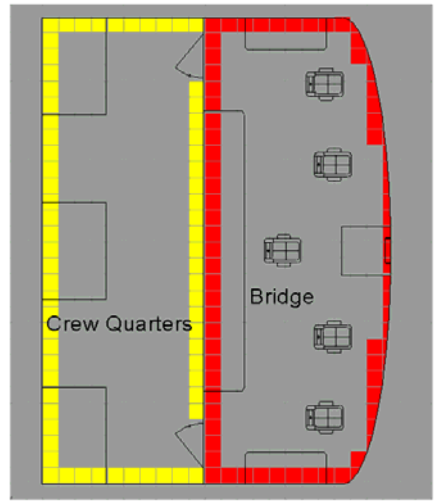


Appendix E – Main Deck General Arrangements



Appendix F – Superstructure Arrangement





Appendix G – Powering and Resistance

HSSL SWATH				
Model				
Length-waterline (ft)	3.786		Ca	0.0002
Length-overall (ft)	4			
Beam-waterline (ft)	0.831			
Beam-overall (ft)	0.9285			
Draft (ft)	0.179			
Disp (lbs)	9.53		PC	0.7
Disp (cu ft)	0.15281			
WS (sq ft)	3.64			
Ship				
Disp (LT)	179			
Disp (cu ft)	6,266			
Scale	34			
Length-waterline (ft)	131			
Length-overall (ft)	138			
Beam-waterline (ft)	29			
Beam-overall (ft)	32			
Draft (ft)	6			
WS (sq ft)	4,329			

Fn	**C_r**	**Ship Speed (knots)**	**Re**	**C_f**	**C_a**	**C_t**	**EHP**	**SHP**
0.194	0.00107	7.45	1.28E+08	0.00201	0.0002	0.00328	51	73
0.258	0.00368	9.92	1.71E+08	0.00193	0.0002	0.00581	213	305
0.323	0.00385	12.42	2.14E+08	0.00187	0.0002	0.00592	427	610
0.388	0.002	14.89	2.57E+08	0.00183	0.0002	0.00403	501	715
0.452	0.00158	17.36	2.99E+08	0.00179	0.0002	0.00357	703	1,005
0.517	0.00225	19.87	3.42E+08	0.00176	0.0002	0.00421	1,242	1,774
0.581	0.00225	22.34	3.85E+08	0.00173	0.0002	0.00418	1,754	2,506
0.646	0.00183	24.81	4.27E+08	0.00171	0.0002	0.00374	2,148	3,068
0.651	0.00183	25.02	4.31E+08	0.00170	0.0002	0.00373	2,201	3,145
0.781	0.00183	30.00	5.17E+08	0.00166	0.0002	0.00369	3,757	5,367

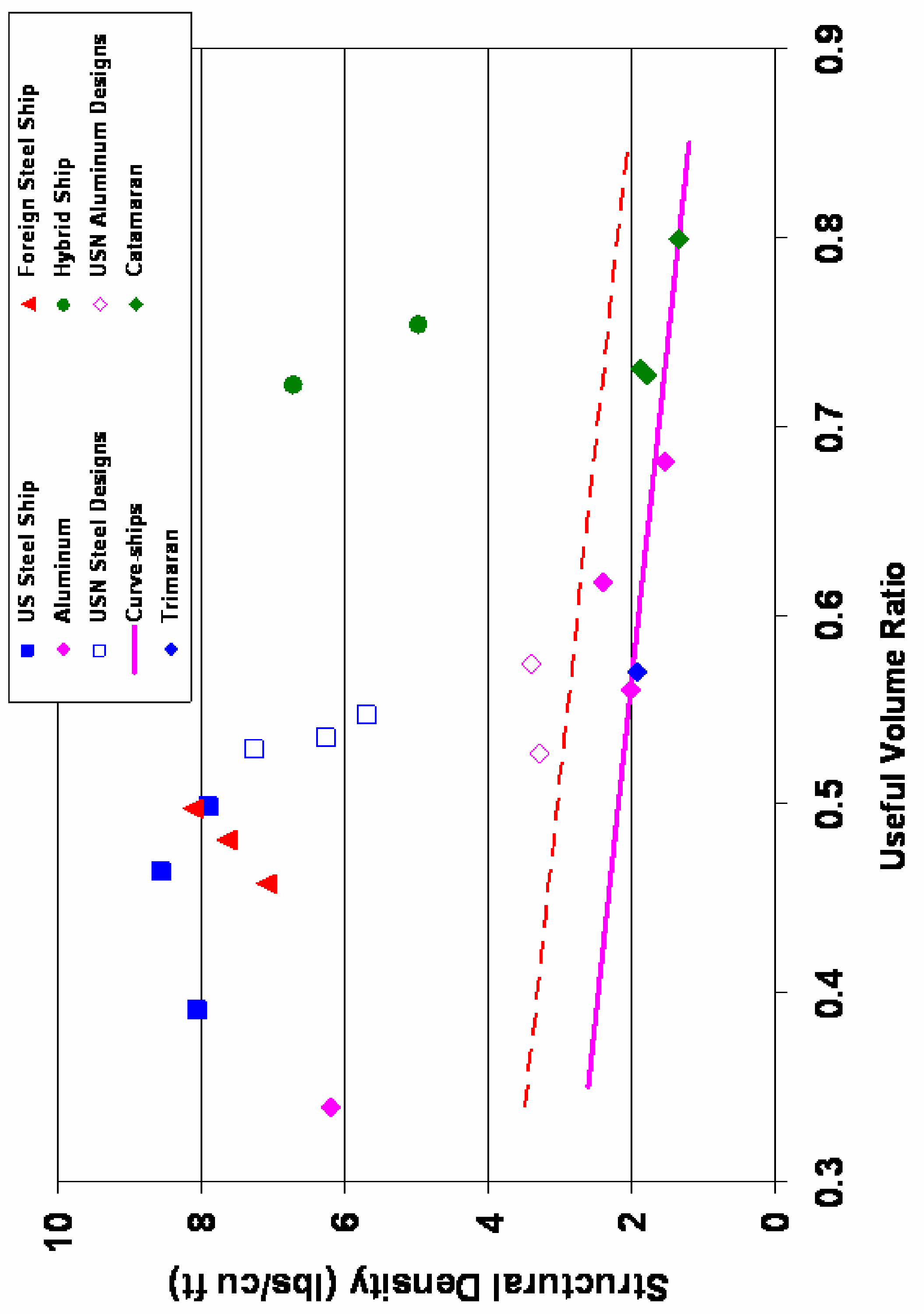
Appendix H – Detailed Weight Breakdown

(Pounds)

W100	**HULL STRUCTURES**	**74,444**
W200	**PROPULSION PLANT**	**83,280**
W230	PROPULSION UNITS	76,560
W233	DIESEL ENGINES	67,560
W235	ELECTRIC PROPULSION	9,000
W300	**ELECTRIC PLANT, GENERAL**	**15,680**
W400	**COMMAND & CONTROL**	**6,350**
W410	COMMAND+CONTROL SYS	2,240
W420	NAVIGATION SYS	2,000
W430	INTERIOR COMMUNICATIONS	560
W440	EXTERIOR COMMUNICATIONS	1,000
W441	RADIO SYSTEMS	200
W443	VISUAL + AUDIBLE SYSTEMS	800
W450	SURF SURV SYS (RADAR)	550
W500	**AUXILIARY SYSTEMS, GENERAL**	**57,218**
W510	CLIMATE CONTROL	12,000
W520	SEA WATER SYSTEMS	4,500
W530	FRESH WATER SYSTEMS	1,600
W550	AIR,GAS+MISC FLUID SYSTEM	3,100
W555	FIRE EXTINGUISHING SYSTEMS	2,200
W556	HYDRAULIC FLUID SYSTEM	900
W560	SHIP CONTROL SYSTEM	6,720
W580	MECHANICAL HANDLING SYSTEMS	29,298
W581	ANCHOR HANDLING+STOWAGE SYSTEMS	5,000
W582	MOORING+TOWING SYSTEMS	2,240
W583	BOATS,HANDLING+STOWAGE SYSTEMS	900
W585	ELEVATING + RETRACTING GEAR	21,158

W600	**OUTFIT+FURNISHING,GENERAL**	**40,000**
800	**DEADWEIGHT**	**94,166**
F10	SHIPS FORCE	800
F12	NON-COMMISSIONED OFFICERS	200
F13	ENLISTED MEN	600
F30	STORES	400
F31	PROVISIONS+PERSONNEL STORES	150
F32	GENERAL STORES	250
F40	LIQUIDS, PETROLEUM BASED	36,766
F41	FUEL OIL	36,366
F42	LUBE OIL	400
F50	LIQUIDS, NON-PETRO BASED	1,100
F51	SEA WATER	
F52	FRESH WATER	500
F54	HYDRAULIC FLUID	500
F55	SANITARY TANK LIQUID	100
F60	CARGO	55,100
900	**MARGINS**	**30,467**
	LIGHTSHIP	**276,972**
	LIGHTSHIP + MARGIN	**307,439**
	LOADS	**94,166**
	FULL LOAD	**401,605**
	FULL LOAD in long tons	179

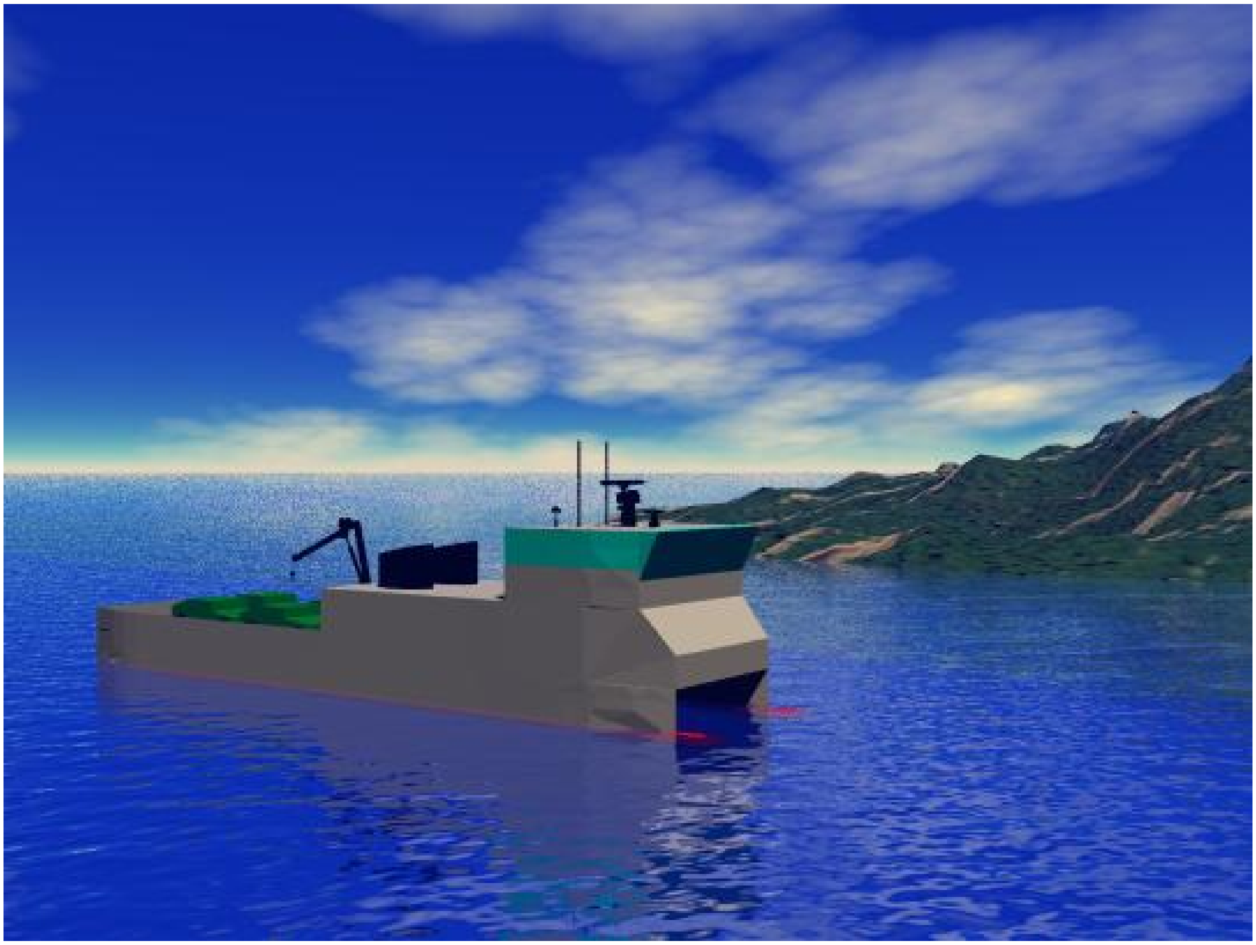
Appendix I – Structural Density Chart

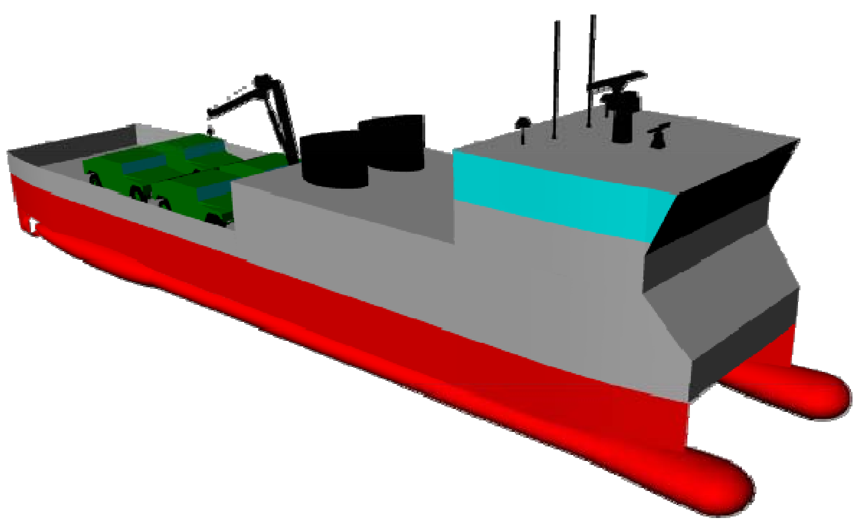


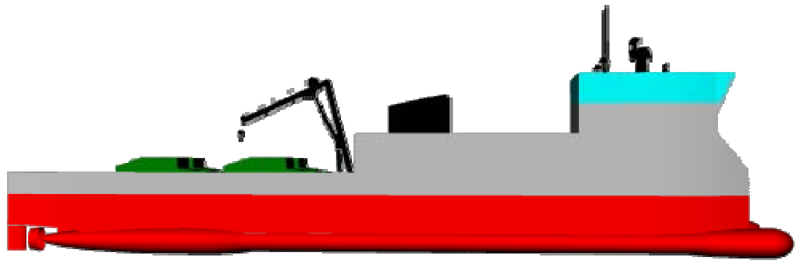
Appendix J – Center of Gravity Calculations

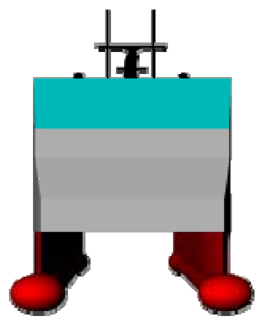
Element	**Weight (lbs)**	**KG (ft)**	**Moment (ft-lbs)**
Hull Structures	74,444	11	818,882
Diesels	67,560	16.85	1,138,386
Electric Motors	9,000	2.69	24,210
Electric Generators	15,680	16.85	264,208
Command and Control	6,350	25.21	160,084
Climate Control	12,000	7	84,000
Water and Fluids Systems	9,200	6	55,200
Crane	21,158	14	29,6218
Mechanical Handling Systems	8,140	12.21	99,389
Outfit and Furnishing	40,000	11	440,000
Cargo	55,100	14.71	810,521
Ships Force	800	27.21	2,1768
Liquids	37,866	2.69	101,860
Stores	400	13	5,200
Fire Fluids	3,100	2.69	8,339
Total	357,698	12.10	4,328,264

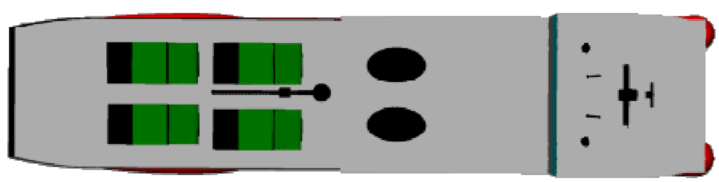
Appendix K – Images

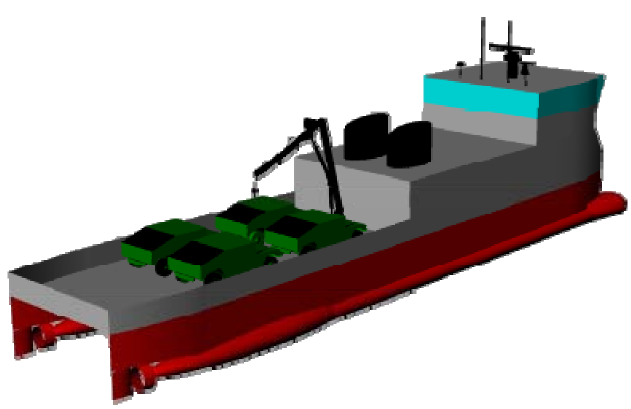


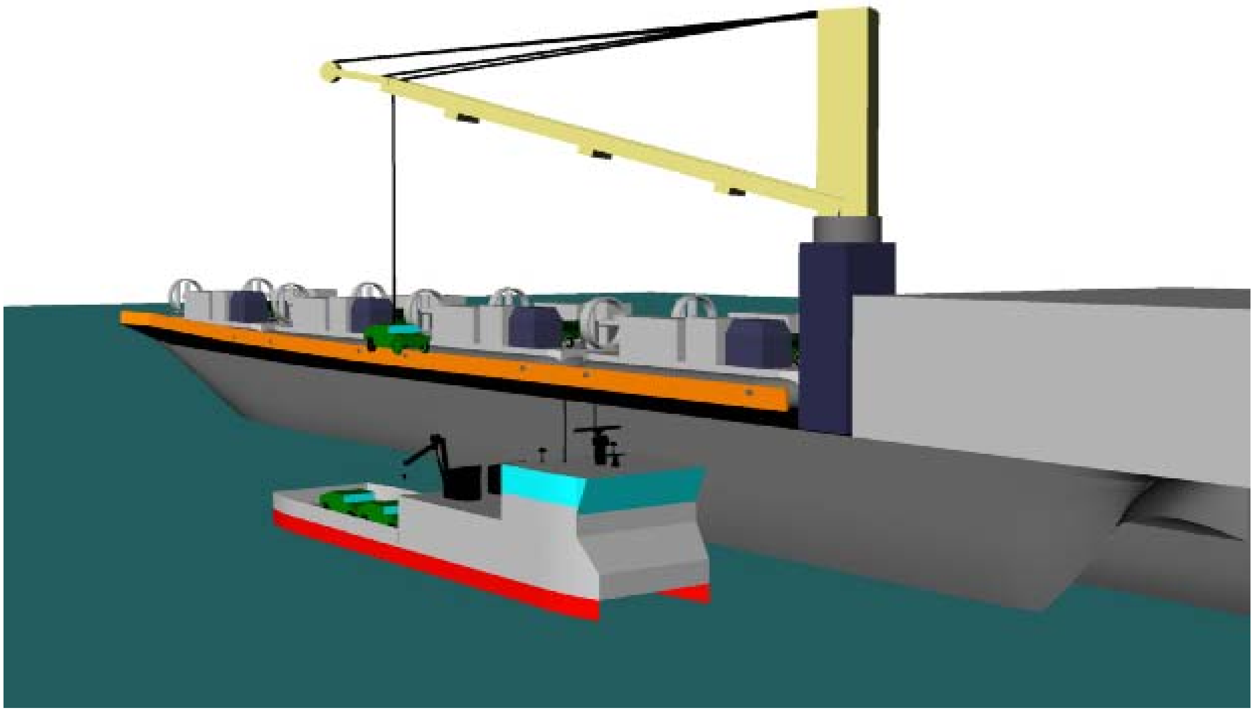


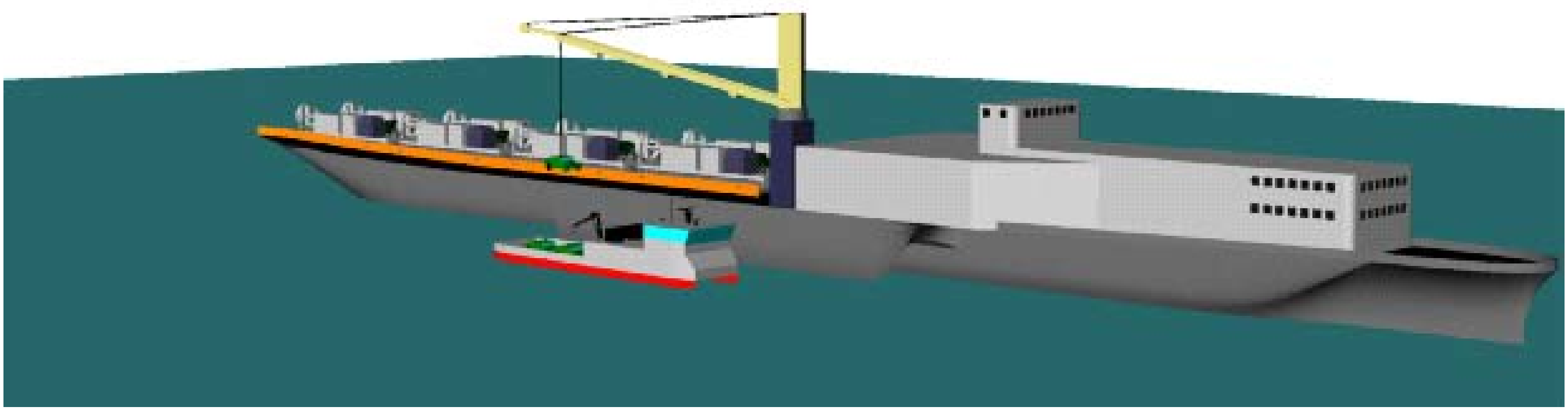












Appendix L – Volume Breakdown

GROUP 1.1		Area (ft^2)	Volume (ft^3)
1.13201	PILOT HOUSE	289	2,312
GROUP 1.4			
1.544	CARGO	2,589	6,837
GROUP 2.1			
2.131101	CREW LIVING SPACE	289	2,312
2.14003	DECK WASHROOM AND WATER CLOSET	53	420
GROUP 2.2			
2.22204	GALLEY	113	902.88
GROUP 3.1			
3.1	STEERING GEAR ROOM	429	2,424
GROUP 3.9			
3.9	PLUMBING WASTE WATER TANK	-	641
3.9	WASTE OIL TANK	-	458
3.91101	FUEL TANK	-	687
3.92002	BALLAST TANK	-	1,056
3.93001	POTABLE WATER TANK	-	320
GROUP 4.3			
4.3	MAIN MACHINERY ROOM	1,038	8,307
GROUP 5.1			
5.1	UNASSIGNED		8,773